

University of California at Berkeley
Physics 129A
Professor Freedman
Fall 2004
September 25, 2004
Homework #4 (Due: Friday October 1)

1. Given the following mass doublets (the units are 10^{-6} u, where u, unified atomic mass unit, is defined for atomic ^{12}C is exactly 12), compute the corresponding values of the atomic mass of ^{37}Cl :

$$\begin{aligned}m(\text{C}_3\text{H}) - m(^{37}\text{Cl}) &= 41922.2 \pm 0.3 \\m(\text{C}_2\text{D}_8) - m(^{37}\text{ClH}_3) &= 123436.5 \pm 0.1 \\m(\text{C}_3\text{H}_6\text{O}_2) - m(^{37}\text{Cl}) &= 104974.24 \pm 0.08\end{aligned}$$

Here $\text{D} = ^2\text{H}$, $\text{C} = ^{12}\text{C}$, and $\text{O} = ^{16}\text{O}$. Include in your calculation the effect of uncertainties in the H, D, O, and C masses. This problem invites you to do some of the manipulations that would have been done by Aston in order to measure the Cl mass. Why did he measure differences in masses instead of just measuring the absolute mass and being done with it?

2. Use the semiempirical mass formula to compute the total binding energy and coulomb energy: (a) ^{21}S (b) ^{20}F (c) ^{238}U . Use the form given in class (see the posted lecture notes). Compare your answer with the correct values that you can find on the web.

3. Using the Semi-empirical mass formula compute the binding energy ^8Be . On the basis of this calculation you should come to the conclusion that ^8Be is a stable nucleus. If you look around you should be able to find a decay scheme for ^8B which beta decays to ^8Be . From this data you will discover that the ground state of ^8Be is not bound, in fact it is unstable to decay into two alpha particles. Try to explain this fact. Hint: Go back and look at the systematics of the experimentally observed binding energies. Is there anything peculiar about ^4He ? Invent a theory (you may want to call it the alpha-bond theory). Try to estimate the energy of the "alpha-bond" by considering ^{12}C as a nucleus made of three alpha particles, which are arranged in a triangle. A famous chemist proposed a theory like this -- can you guess the name of the chemist?

4. If the stable isotope of Sodium is ^{23}Na what kind of radioactivity do you expect from (a) ^{22}Na and (b) ^{24}Na . Use the semi empirical mass formula to estimate the Q values for the processes in (a) and (b).

5. Using the single-particle shell model predict the J^π of: $^{15}_7\text{N}$, $^{27}_{12}\text{Mg}$, $^{87}_{38}\text{Sr}$, $^{167}_{68}\text{Er}$, and $^{195}_{80}\text{Hg}$. Compare with the measured value of J^π . Part of your job is to find the measured values (you may want to look in the Table of Isotopes). Comment on any discrepancies between your predictions and the measured values. Can you think of a way of measuring some of these spins and parities?